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SUMMARY REPORT 7 / June 1979

SEA/ShORE ROTATION

Donald Maurer

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1. The subject study developed two models that improve the Navy's ability to balance competing considerations of retention, morale, and sea/shore distribution. The models capture the interrelationships of rotation, billet structure, continuation behavior, and personnel inventory.

2. The Aggregate Model predicates a steady-state first-term and career force and is useful in analyzing CNO Program Analysis Memorandum (CPAM) issues that involve rotation policy. The Expanded Model dynamically simulates personnel flows and is useful in managing specific rating and detailing communities. The models have been turned over to the DCNO (Manpower, Personnel and Training) and the Commander, Naval Military Personnel Command. NMPC-49 is the manager of the Expanded Model.

3. Enclosure (1) is forwarded.

M. S. HOLCOMB
Vice Admiral, U.S. Navy
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SUMMARY REPORT 7 / June 1979

SEA/SHORE ROTATION

Donald Maurer

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INTRODUCTION

The purpose of the Sea/Shore Rotation Study is to develop models which enhance the Navy's ability to balance competing considerations of sea/shore distribution, retention, and morale. An example of the importance of controlling the distribution of personnel is provided by the implementation of the Fleet Readiness Improvement Program (FRIP). Abrupt detailing changes were made to rapidly build up required sea manning levels. Consequently, the Navy has experienced an overload as the personnel sent to sea all rotate to shore at the same time.

Effective planning requires knowledge of what distribution of personnel between duty types will result if a particular rotation pattern is followed, or, conversely, what rotation pattern (if any) will produce a desired distribution. One of the most important recurring questions faced by the Navy is how many shore billets are needed to support desired sea manning levels. In planning for new ships or squadrons, the Navy must make certain that the number of shore billets available for rotation is consistent with increased (or decreased) sea billet requirements.

Recognizing the importance of these issues, the Navy requested a study "to construct a model that reflects the interrelationships of sea/shore rotation, continuation, billet structure and personnel inventory" (reference 1).

Two models were developed. One is an aggregate model based on a simplified force structure and steady-state assumption. It was adopted by Op-96 for use in the analysis of CPAM issues. The other is an expanded model based on a more detailed dynamic simulation of personnel movements in a rating or detailing community. This model will be incorporated into the Op-01/NMPC manpower/personnel system for use by Enlisted Rating Coordinators in the management of their ratings and NMPC in the management of inventory balance between sea and shore communities.

THE ROTATION MODELS

The aggregate and expanded sea/shore rotation models described the correspondence between rotation patterns and the distribution of personnel among duty type assignments. Accessions determine the size of the Navy's personnel inventory; continuation rates determine the length of service (LOS) profile, and promotion behavior determines the paygrade distribution. Therefore each of these factors has an important role in the analysis of rotation. Although changes in rotation may influence continuation behavior, the relationship is unknown, probably complex, and quite possibly changing through time. Therefore, in our analysis continuation rates are determined outside the model.

If changes in rotation are considered likely to affect continuation, the user of the aggregate model can solve for a range of values of the continuation parameters. In the expanded model, *expected* changes in continuation can be used as part of the input data; thus, as reliable methods are developed for forecasting the effect on continuation of such factors as Navy policy changes (e.g., the retirement system) or civilian employment opportunities they can be incorporated in the model. We shall now briefly describe the two models.

THE AGGREGATE MODEL

The aggregate model (reference 2) is based on a simplified description of the sea/shore rotation process. Enlisted personnel are divided into two experience categories: first-term personnel who have finished training and are serving their first sea or shore duty tour (there are only two duty types in this model), and career personnel who have completed their first duty tour. At the end of their first tour, personnel who continue in the Navy are assigned to the other type of duty. Thereafter, if they stay in the Navy they are rotated at the end of each tour to the other duty type. This rotation is described by (a:b), the lengths of the career sea and career shore tours respectively. These personnel flows are diagrammed in figure 1. The rectangles represent the four experience/duty categories, and the arrows represent associated flows. The arrows labeled ℓ_i ($i=1,2$) represent losses to the career force. The numbers were used in the CPAM-80 analysis, and represent the present billet structure and continuation behavior for the non-student male component of the Navy minus approximately 10 ratings that have an unusually large shore billet to sea billet ratio.

When the number of personnel in each category remains the same, the system is said to be in balance. If it is assumed that accessions to each of the first-term categories are constant each period, then a balanced system is characterized by two conditions: (1) the losses to the career force are equal to the gains from the first-term force; and (2) the number of personnel rotating to sea is equal to the number of personnel rotating to shore.

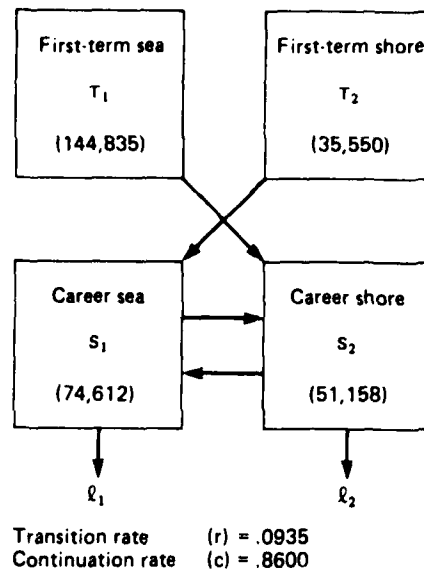


FIG. 1: FLOWS IN THE AGGREGATE MODEL

The flows are determined by continuation behavior and the length of the duty tours. Two group continuation rates are used by the aggregate model. The career continuation rate (c) is the percentage of all personnel in the career group who remain in the Navy to the next period. According to figures developed by Op-96 (reference 3), for the last three years this has been approximately 85 percent. The computation of c from the more familiar LOS continuation rates is developed in reference 2.

The first-term continuation rate (r) is not a true continuation rate but a transition rate. It represents the percentage of all first-term personnel in functional billets (i.e., billets affected by sea/shore rotation) who remain in the Navy at the beginning of the 5th year. The computation of the transition rate is given in the appendix since it does not appear in any other reference.

The model assumes that the first tour for personnel assigned to sea and shore duty occurs at the same time in their careers and that continuation rates are the same at both sea and shore duty. While these assumptions are not essential, they do simplify the analysis.

Any particular continuation behavior (c, r) and rotation pattern ($a:b$) will determine a corresponding balanced system (T_1, T_2, S_1, S_2). This static distribution gives the actual number of personnel who will be in each of the four categories

if the specified continuation and rotation behavior is realized. The two conditions for this balanced system can be expressed mathematically by the simultaneous equations (reference 2)

$$r(T_1 + T_2) - (1-c)(S_1 + S_2) = 0$$

$$rT_1 + ca\left(\frac{1-c}{1-ca}\right)S_1 - \left(\frac{1-c}{1-cb}\right)S_2 = 0.$$

The analysis of the aggregate model as defined by this pair of equations consists of a description of the interrelationships which are imposed on T_1 , T_2 , S_1 , S_2 , a , b , c , and r .

This steady-state model has been used to answer specific Naval personnel questions such as:

- How many shore billets are required for rotation? The force structure in figure 1 was analyzed in reference 2. The results showed that if a rotation policy of 3 years at sea and 3 years ashore was followed, the Navy would need 85,801 more shore billets than it presently has. However, a rotation pattern of 4 years at sea and 2 years ashore would require only 293 additional shore billets.
- What sea/shore rotation pattern is best suited to the Navy's present billet structure and continuation characteristics? The results (reference 2) show that a rotation pattern of 5 years at sea and 2½ years ashore is the best policy for the force structure in figure 1.
- How many women and civilians can be substituted in a given rating to give rotating personnel a 3 year sea/shore rotation pattern? This question was answered for the air controlman rating (reference 7). The results showed that 820 shore billets were needed for rotation, and the remaining 992 could be filled by women or civilians.

THE EXPANDED MODEL

Since the aggregate model is a steady-state model based on several simplifying assumptions about sea/shore rotation, we developed an expanded model (reference 4) that provides a more accurate simulation of personnel movements. The model can:

- describe a community whose inventory is variable over time,
- treat each paygrade separately,
- use continuation rates for each duty type and LOS category,
- simultaneously consider different rotation patterns for each paygrade, and
- compute promotions into each paygrade.

The expanded model can be used by Enlisted Rating Coordinators (ERC) in managing their ratings and NMPC in managing inventory balance between sea and shore. For example, an ERC may want to know what effects a change in E-3 rotation would have on sea and shore distributions in higher paygrades. In applying the model to sample ratings, we found that because of promotions out of E-3, this effect could be significant. A second kind of question is more general: what changes in current policies need to be made to attain a desired inventory profile? To illustrate, our projection of the SeaBee community (reference 4), using current continuation rates and accessions, predicts a total loss of 1,134 personnel within five years, of which 947 will be from sea duty. If this were an acceptable reduction in size, but the loss of personnel from sea was considered too high, the expanded model could be used to determine alterations in rotation and accessions that would help maintain a more stable sea contingent in each paygrade.

Since a detailed account of the expanded model is available in reference 4, we shall summarize only its salient features here. There are three duty types: sea, shore, and neutral. The user defines the number of paygrade groups, the number of LOS categories, and the maximum possible tour length. If the LOS categories represent years, then the maximum tour length is measured in quarters. The model can be applied to the total Navy as well as to a specific detailing community.

The expanded model is a network flow model in which the nodes represent the personnel inventory classified by duty type, LOS, and projected rotation date (PRD).¹ The flow paths are defined by the rotation pattern, and the magnitudes of flows along these paths are determined by continuation rates and promotion probabilities. The main program in the model projects a starting personnel inventory to future periods. Figure 2 shows the steps required.

In the first step, the continuing inventory is determined by multiplying the total number of personnel in each LOS category by the corresponding continuation rate for that LOS.

Next, promotions out of each paygrade group are computed. Historical promotion data are used. In the calculation, these "normal" promotion rates are adjusted in response to variations in continuation, accessions, and endstrength requirements.

After promotions, each paygrade inventory is rotated. Normally all personnel in the same LOS having the same PRD would rotate together. However, billets in each duty type must be filled, and Navy detailers have difficulty filling billets while adhering to a strict rotation pattern. Therefore, we incorporated a rotation pattern which allows for controlled variation in tour lengths. For example, the

¹Ordinarily, the PRD means time remaining until transfer to another station, possibly in the same duty type. In this study, PRD will mean time until rotation to a *different* duty type.

user could specify a rotation pattern in which 90 percent of the rotating personnel have a tour length of 12 quarters, while the remaining 10 percent are distributed between 13 and 14 quarters. Moreover, this distribution can be varied from period to period.

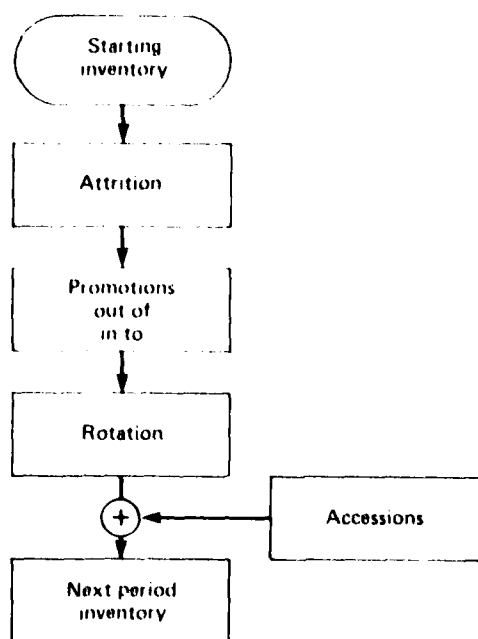


FIG. 2: FLOW DIAGRAM OF THE PROJECTION

In the normal rotation pattern, an individual's PRD decreases by 1 each quarter. But empirical evidence indicates that a significant portion of the inventory does not fit the normal pattern. For example, the PRDs of individuals in the Mess Management Specialist (MS) rating in 1976 and 1977 were compared (reference 6). In 1976, there were 653 MSs on shore duty with a PRD of 5 quarters. In 1977, four quarters later, all of these people were still in the Navy; however, only 440 had a PRD of 1. This means that approximately 200 had their PRDs changed. Further analysis indicated that most of these rotation dates had been extended. Other ratings we examined also showed similar discrepancies (although not as extreme).

These changes in PRD dates are probably due to factors such as extensions to keep billets filled, humanitarian considerations, leave taken between tours, and school attendance. To adjust the normal rotation pattern to account for these factors, the user can specify percentages for early and late rotation.

The final step in the projection process is the addition of accessions to give the next period's inventory. The historical data base for this projection can be obtained from the Enlisted Master Record (EMR) maintained by NMPC. The data for making future projections can be estimated by altering this historical input so that it conforms to expected changes. Continuation rates could also be obtained from the PROPHET model (reference 5).

Table 1 (from reference 6) shows the percent of error in the model's projections for several ratings when compared to the historical results from the EMR tapes. By comparing the September 1976 and September 1977 tapes, we determined continuation rates, promotion probabilities, accessions, and early and late rotation data. Using this data we projected the September 1976 inventory to September 1977. Then we determined the percent of this projected inventory who were in the wrong duty type when compared with the September 1977 EMR tapes. Most of the differences in table 1 are under two percent, with the exception of the E-7 and E-8 paygrades of the AQ community — two very small groups. The absolute differences in sea/shore distribution for these two paygrades are only 10 and 5, respectively.

TABLE 1
COMPARISON OF PROJECTIONS AND INVENTORIES

Rating/ community	Paygrade						
	<u>1,2,3</u>	<u>4</u>	<u>5</u>	<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>
AQ	0.0	0.8	0.2	0.9	4.7	4.5	-
MS	0.8	2.1	0.1	0.2	0.4	1.5	0.1
SeaBees	0.4	0.6	1.7	1.3	1.3	2.2	0.0

CONCLUSIONS AND RECOMMENDATIONS

From our general analysis of the sea/shore rotation process we conclude that:

- All personnel management factors involved in sea/shore rotation are inter-related, and alterations in one will produce corresponding alterations in others (references 2, 3 and 4). In particular, desirable rotation policies may not be compatible with Navy billet requirements; e.g., a rotation pattern consisting of equal sea and shore tour lengths is not feasible with the current or foreseeable billet structure.
- Changes in continuation behavior, due to changing opportunities in the civilian sector as well as Navy policy decisions, will affect sea/shore rotation (reference 3). Thus a fixed rotation pattern may not provide desired sea/shore distributions over an extended period of time.
- In actual practice, rotation behavior diverges sharply from the stated policies. According to data supplied by the Naval Military Personnel Command, rotating personnel are distributed over several tour lengths. In some ratings early and late rotation is a significant factor in the rotation process (reference 6).
- To reduce its requests for shore billets while maintaining desired sea manning levels, the Navy can (1) increase continuation or (2) alter rotation patterns to increase the length of sea tours (reference 3).

In view of these conclusions, we recommend that these models be included in the enlisted personnel management system to help manage sea/shore rotation. Controllable parameters — accessions, continuation, promotions, and normal rotation patterns — can be used to attain desired endstrengths and duty type distributions of personnel if a more general definition of rotation is adopted. For example, a less disruptive increase in sea tour lengths can be made by increasing the percentage of personnel who are sent to longer sea tours rather than increasing everyone's tour length. This will not entirely alleviate the conflict between Navy manning goals and equitable rotation patterns; however, if the effects of policy changes can be anticipated, the planner can use the controllable parameters to make gradual changes over several periods to compensate for the rotation effects of these policy decisions. In this way the negative effect of disruptive rotation changes on morale can be minimized.

Furthermore, in view of the need to reduce shore billet levels, the Navy should investigate the possibility of implementing a program of incentives, such as higher sea pay or a bonus similar to the SRB, to make marginally acceptable tour lengths more attractive and thus increase the Navy's control of rotation. Also, incentive programs to increase retention could reduce the need for extreme rotation patterns.

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APPENDIX

COMPUTATION OF THE FIRST-TERM TRANSITION RATE

<u>LOS</u>	<u>Number retained</u>	<u>Approx. number in functional billets</u>
1	79 x 0.5	40
2	68 x 0.7	48
3	61	61
4	<u>58</u>	<u>58</u>
	Total 266	207
	19	19
		19
		<u>207</u> = 0.0918

Transition rate:

The first column represents years in service. For each 100 new recruits, the second column is the number who remain in service after each of four years. The sixth row is the number who remain in the Navy at the beginning of the 5th year. On the basis of figures supplied by Op-96, we estimate that of the 79 survivors in year 1, 50 percent are in functional billets. Approximately 70 percent of the second year survivors occupy functional billets. The third column gives the number of survivors in functional billets. Thus in a steady-state force the transition rate is given by the number of reenlistees divided by the total number of first-termers in functional billets.